MEng in Electronic & Computer Engineering

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***Abstract*—An existing class of heuristic models of diffuse scattering are elaborated and applied to a setup consisting of a plane wave incident on a sinusoidally shaped wall. Results are compared to full-wave method-of-moments (MoM) model, and also to Geometrical Optics (GO) and Physical Optics (PO) approximations.**

***Index Terms*—Diffuse Scattering, Diffuse Reflection, Channel Model, Ray Tracing, Ray Shooting.**

I. Introduction

TBD.

II. Model

In this model [1], the scattered electric field E_s is assumed to propagate from each surface element dW along a wall according to a mix of components:

$$E_s = E_L + E_R + E_T, \tag{1}$$

where

- E_L is a perfectly diffuse (Lambertian) component satisfying
$$|E_L|_{dS} = S|E_i|_{dS} \tag{2a}$$
$$|E_L| \propto \sqrt{\cos(\theta_s)}, \tag{2b}$$
where θ_s is the scattering angle with respect to the wall normal,
- E_R is the (reduced) specular component of Geometrical Optics satisfying
$$|E_R|_{dS} = R|\Gamma||E_i|_{dS}, \tag{3}$$
where Γ is obtainable via classical Fresnel formulae and R is introduced to reduce the specular component in favour of the diffuse component,
- E_T is the transmitted component through the wall, satisfying
$$|E_T|_{dS} \propto |E_i|_{dS}, \tag{4}$$
i.e. this component is geometry independent and only depends on constitutive parameters.

Thus, in addition to the (reduced) specular component of Geometrical Optics, $E_{\text{GO,r}}$ each point in the middle of a surface element dW gives a diffuse contribution dE_d to the scattered field E_s whose amplitude $|dE_d|$ is given by

$$|dE_d| \propto \sqrt{\frac{dW \cos\theta_i \cos\theta_d}{\pi}\frac{1}{r_i r_d}} \tag{5}$$

with the constant of proportionality depending on the incident amplitude and a scattering parameter S. Specifically, we have

$$|dE_d| = S\Upsilon\sqrt{dW}, \quad \text{where} \tag{6a}$$

$$\Upsilon = \sqrt{\frac{60 G_t P_t \cos\theta_i \cos\theta_d}{\pi}\frac{1}{r_i r_d}} \tag{6b}$$

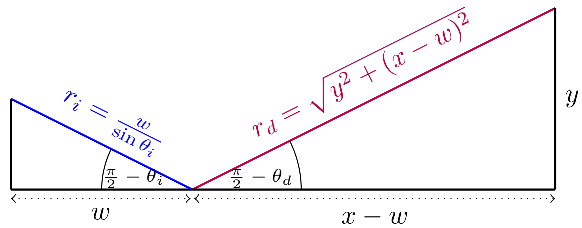

Fig. 2. Geometry setup implies that $\frac{1}{r_i r_d} = \frac{\sin\theta_i}{w\sqrt{y^2+(x-w)^2}}$, and $\cos\theta_d = \frac{y}{\sqrt{y^2+(x-w)^2}}$

1) Uniform Plane Wave Incident on PEC: We start with a setup as per Figure 1.

$$k_i = \sin(\theta_i)\mathrm{e}_x - \cos(\theta_i)\mathrm{e}_y \tag{7a}$$
$$k_r = \sin(\theta_i)\mathrm{e}_x + \cos(\theta_i)\mathrm{e}_y \tag{7b}$$
$$k_d = \sin(\theta_d)\mathrm{e}_x + \cos(\theta_d)\mathrm{e}_y \tag{7c}$$

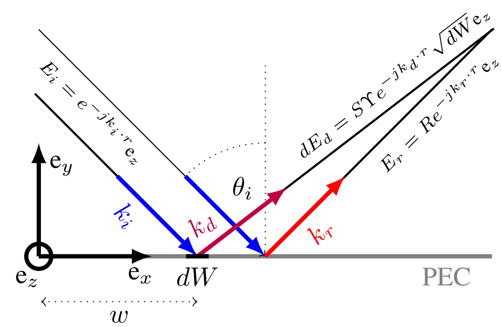

Fig. 1. A uniform plane wave strikes a PEC. The overall scattered wave is $E_s = E_r + \int_W dE_d$. E_r is just the usual specular component of geometrical optics, multiplied by R, a roughness parameter. E_d is the diffuse component - a sum of non-coherent contributions along the wall, one of which is shown here, for a drawn surface element dW.

Then, since $G_t = 1$ (0 gain), $P_t = 1$ (uniformity of wave), $dW = hdx$, $|\Gamma| = 1$, and referring to the geometry of Figure 2, we get

$$E_i = e^{-j(x\sin\theta_i - y\cos\theta_i)}\mathrm{e}_z \tag{8a}$$

$$E_r = \sqrt{1-S^2}\ e^{-j(x\sin\theta_i + y\cos\theta_i)}\mathrm{e}_z \tag{8b}$$

$$E_d = S\ \sin\theta_i\sqrt{\frac{60hy\cos\theta_i}{\pi}}\int_W \frac{1}{w}\sqrt{\frac{dw}{(y^2+(x-w)^2)^{\frac{3}{2}}}}\, e^{-j\left(\frac{x^2+y^2-xw}{\sqrt{y^2+(x-w)^2}}\right)}\mathrm{e}_z \tag{8c}$$

REFERENCES

[1] V. Degli-Esposti and H. Bertoni, "Evaluation of the role of diffuse scattering in urban microcellular propagation," in *Gateway to 21st Century Communications Village. VTC 1999-Fall. IEEE VTS 50th Vehicular Technology Conference (Cat. No.99CH36324)*, vol. 3, 1999, pp. 1392–1396 vol.3.